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GEORGIA INSTITUTE OF TECHNOLOGY
Engineering Experiment Station

PROJECT INITIATION

Date: October 25, 1974

Project Title: Aera Manpower Projection Model

Project No.: A-1675

Project Director: Mr. L. D. Holland

Sponsor: Southern Regional Education Board, Atlanta, Ga.

Effective 9/6/74 Estimated to run until 12/6/74

Type Agreement: Modified Std. Ind. dtd 9/6/74 Amount: $ 5,398.00

Reports Required: Monthly Status Letters, Final Technical Report

Sponsor Contact Person (s):

Dr. E. F. Schielinger
Director of Research
Southern Regional Education Board
130 Sixth Street, N.W.
Atlanta, Ga. 30313

Assigned to RADAR Division

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GEORGIA INSTITUTE OF TECHNOLOGY
ENGINEERING EXPERIMENT STATION

PROJECT TERMINATION

Date: October 16, 1975

Project Title: Area Manpower Projection Model

Project No.: A-1675

Project Director: Mr. L. D. Holland

Sponsor: Southern Regional Education Board, Atlanta, Georgia

Effective Termination Date: June 5, 1975 (Contract Expiration)

Clearance of Accounting Charges: By June 30, 1975

Grant/Contract Closeout Actions Remaining: NONE

Assigned to: Applied Engineering Laboratory

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File: A-1675

ENGINEERING EXPERIMENT STATION
GEORGIA INSTITUTE OF TECHNOLOGY • ATLANTA, GEORGIA 30332

14 October 1974

Southern Regional Education Board (SREB)
130 Sixth Street, N.W.
Atlanta, Georgia 30313

Attention: Dr. E. F. Schietinger
Director of Research

Reference: Georgia Tech Project No. A-1675

Subject: Monthly Technical Progress and Financial Report No. 1
"Area Manpower Projection Model"

Gentlemen:

A summary of the progress for the period 12 September through 12 October 1974 is contained herein.

I. Introduction

The overall objectives of this program are the following: (1) to convert approximately six data tapes from IBM System 360 track and parity to Univac 1108 track and parity; (2) to develop a digital program which will accept the Univac 1108-compatible data tapes and appropriately process the data; (3) to apply the program to approximately sixteen data tapes; and (4) to provide assistance to SREB personnel in the integration of the above program and data into an overall manpower projection model program.

II. Technical Progress Summary

Five IBM-compatible tapes (four state tapes and the USA data tape) have been supplied by SREB and have been converted to Univac-compatible tapes. The necessary programs for reading, summing, allocating, and aggregating the state data matrices have been developed and successfully applied to the North Carolina data tape such that Task 1 has been completed. Tasks 2, 3, and 4 have been carried out for one of the fourteen states. The other state tapes will be routinely processed using the same programs.

III. Current Problems

There are currently no problems that impede performance on the project.

IV. Work Planned

The remaining 13 state matrices will be processed to complete Tasks 2, 3, and 4, and the computer programs necessary for processing the USA data tape will be developed and applied. It is anticipated that this work, which will complete Tasks 1 through 5 and about one-half of Task 6, will be completed by mid-November.

V. Financial Report

Project financial data are processed on a calender month basis, and the most recent data available on this project covers the period from 12 September (contract starting date) to 30 September 1974. Charges for computer time and for the personnel retirement fund lag somewhat and have not yet been expensed. Charges expensed during September for personal services and associated overhead totaled $1,571.87, as compared with the budgeted sum of $3,749.00. This rate of expenditure is consistent with the project plan, and the remaining funds are deemed sufficient to accomplish the goals of the project.

Respectfully submitted,

L. D. Holland
Project Director

Approved:

R. P. Zimmer
Manager, Systems Analysis Technical Area
Radar Division

RPZ/ja

A-1675

ENGINEERING EXPERIMENT STATION
GEORGIA INSTITUTE OF TECHNOLOGY • ATLANTA, GEORGIA 30332

12 November 1974

Southern Regional Education Board (SREB)
130 Sixth Street, N.W.
Atlanta, Georgia 30313

Attention: Dr. E. F. Schietinger
Director of Research

Reference: Georgia Tech Project No. A-1675

Subject: Monthly Technical Progress and Financial Report No. 2
"Area Manpower Projection Model"

Gentlemen:

A summary of the progress for the period 13 October through 6 November 1974 is contained herein.

I. Introduction

The overall objectives of this program are the following: (1) to convert approximately six data tapes from IBM System 360 track and parity to Univac 1108 track and parity; (2) to develop a digital program which will accept the Univac 1108-compatible data tapes and appropriately process the data; (3) to apply the program to approximately sixteen data tapes; and (4) to provide assistance to SREB personnel in the integration of the above program and data into an overall manpower projection model program.

II. Technical Progress Summary

At the end of the previous reporting period, the five IBM-compatible data tapes supplied by SREB had been converted to Univac-compatible tapes, and the computer programs necessary for reading, summing, allocating, and aggregating the state data matrices had been developed and applied to one of the fourteen state tapes.

During this reporting period, the above programs have been applied successfully to the remaining thirteen states to complete the operations required on the state data matrices (Tasks 1 through 4). Task 5 calls for the application of these same programs to two matrices of U.S.A. data; however, the U.S.A. data tape available-to and supplied-by SREB turned out to be in a form quite different from the individual state data matrices. As a result, it was necessary to rewrite the programs for reading and aggregating before processing the two U.S.A. data matrices. The necessary programs were written and the 1970 and 1980 U.S.A. industry/occupation matrices were reduced to forms compatible with the final form of the state data matrices. The 1980 data elements were divided by the corresponding 1970 elements to produce the ratios required in Task 5, thus completing that task. Also during this reporting period, an effort was begun to read and interpret occupational separation rate data contained on the original U.S.A. data tape. The retreival and generation of the separation data and the unanticipated writing of extra programs for handling the U.S.A. data were accomplished under Task 8.

III. Current Problems

There are currently no problems that impede performance on the project.

IV. Work Planned

Tasks 6 and 7, which respectively require storing the project's resultant data on a magnetic tape and preparing a report documenting the project models and programs, will be accomplished during the remaining month of the contract (7 November to 6 December 1974).

V. Financial Report

Charges expensed for October were $1,818.83, as compared with $1,571.87 expensed for September and a budget total for the project of $5,398.00,

to leave an apparent free balance of $2,007.30. Charges for computer time used thus far (approximately $500) and for October retirement charges (approximately $100) are yet to be expensed. The current rate of expenditure is consistent with the project plan, and the remaining funds are deemed sufficient to accomplish the goals of the project.

Respectfully submitted,

L. D. Holland
Project Director

Approved:

R. P. Zimmer
Manager, Systems Analysis Technical Area
Radar Division

LDH/ja

ENGINEERING EXPERIMENT STATION
GEORGIA INSTITUTE OF TECHNOLOGY • ATLANTA, GEORGIA 30332

18 December 1974

Southern Regional Education Board (SREB)
130 Sixth Street, N.W.
Atlanta, Georgia 30313

Attention: Dr. E. F. Schietinger
Director of Research

Reference: Georgia Tech Project No. A-1675

Subject: Monthly Technical Progress and Financial Report No. 3
"Area Manpower Projection Model"

Gentlemen:

A summary of the progress for the period 6 November through 5 December 1974 is contained herein.

I. Introduction

The overall objectives of this program are the following: (1) to convert approximately six data tapes from IBM System 360 track and parity to Univac 1108 track and parity; (2) to develop a digital program which will accept the Univac 1108-compatible data tapes and appropriately process the data; (3) to apply the program to approximately sixteen data tapes; and (4) to provide assistance to SREB personnel in the integration of the above program and data into an overall manpower projection model program.

II. Technical Progress Summary

During this reporting period, the Tasks of the original contract were completed. The data transformations were completed; a computer tape containing the project results was created and made available for SREB's use; and a technical report describing the project activities and results was prepared. At the end of this reporting period, the technical report had been approved and was being reproduced for distribution.

III. Current Problems

There are currently no problems that impede performance on the project.

IV. Work Planned

Since the establishment of the original contract in September of this year, there have been two additions to the contract. The first was for "additional computer use" and will require only minimal personal services by EES. The second was primarily for the purchase of six computer tapes containing intermediate data generated during the original contractual effort. Completion of the tape purchase/transfer is anticipated during the December/January reporting period.

V. Financial Report

Charges expensed for November were $758.10, as compared with $1,818.83 expensed for October and a budget total for the project of $5,518.00, to leave an apparent free balance of $1,369.20. Charges for recent computer time and for November retirement charges (as well as all December charges) are yet to be expensed. The remaining funds are deemed sufficient to complete the goals of the project.

Respectfully submitted,

L. D. Holland
Project Director

Approved:

R. P. Zimmer
Manager, Systems Analysis Technical Area
Radar Division

LDH/ja

ENGINEERING EXPERIMENT STATION
GEORGIA INSTITUTE OF TECHNOLOGY • ATLANTA, GEORGIA 30332

17 January 1975

Southern Regional Education Board (SREB)
130 Sixth Street, N.W.
Atlanta, Georgia 30313

Attention: Dr. E. F. Schietinger
Director of Research

Reference: Georgia Tech Project No. A-1675

Subject: Monthly Technical Progress and Financial Report No. 4
"Area Manpower Projection Model"

Gentlemen:

A summary of the progress for the period 6 December 1974 through 5 January 1975 is contained herein.

I. Introduction

The overall objectives of this program are the following: (1) to convert approximately six data tapes from IBM System 360 track and parity to Univac 1108 track and parity; (2) to develop a digital program which will accept the Univac 1108-compatible data tapes and appropriately process the data; (3) to apply the program to approximately sixteen data tapes; and (4) to provide assistance to SREB personnel in the integration of the above program and data into an overall manpower projection model program.

II. Technical Progress Summary

The primary tasks were accomplished prior to this reporting period. Current technical activity consists of provision of Univac 1108 computational time and consulting services as required.

III. Financial Report

Charges expensed for December were $997.86, and the total expensed charges (through December) are $5,146.66, leaving an apparent free balance

of $371.34. Charges for recent computer time and for December retirement are yet to be expensed.

Respectfully submitted,

L. D. Holland
Project Director

Approved:

R. P. Zimmer
Manager, Systems Analysis Technical Area
Radar Division

LDH/ja

A-1675

ENGINEERING EXPERIMENT STATION
GEORGIA INSTITUTE OF TECHNOLOGY • ATLANTA, GEORGIA 30332

12 February 1975

Southern Regional Education Board (SREB)
130 Sixth Street, N.W.
Atlanta, Georgia 30313

Attention: Dr. E. F. Schietinger
Director of Research

Reference: Georgia Tech Project No. A-1675

Subject: Monthly Technical Progress and Financial Report No. 5
"Area Manpower Projection Model"

Gentlemen:

A summary of the progress for the period 6 January 1975 through 5 February 1975 is contained herein.

I. Introduction

The overall objectives of this program are the following: (1) to convert approximately six data tapes from IBM System 360 track and parity to Univac 1108 track and parity; (2) to develop a digital program which will accept the Univac 1108-compatible data tapes and appropriately process the data; (3) to apply the program to approximately sixteen data tapes; and (4) to provide assistance to SREB personnel in the integration of the above program and data into an overall manpower projection model program.

II. Technical Progress Summary

The primary tasks were accomplished prior to this reporting period. Current technical activity consists of provisions of Univac 1108 computational time and consulting services as required.

III. Financial Report

Charges expensed for January were $265.89, and the total expensed charges (through January) are $5,412.55, leaving an apparent free balance

of $105.45. Charges for recent computer time are yet to be expensed, and the $900 addition to the contract (Dr. Godwin's letter of 14 January 1975) is not reflected in the above figures.

Respectfully submitted,

L. D. Holland
Project Director

Approved:

for R. P. Zimmer
Manager, Systems Analysis Technical Area
Radar Division

LDH/ja

A-1675

ENGINEERING EXPERIMENT STATION
GEORGIA INSTITUTE OF TECHNOLOGY • ATLANTA, GEORGIA 30332

19 March 1975

Southern Regional Education Board (SREB)
130 Sixth Street, N.W.
Atlanta, Georgia 30313

Attention: Dr. E. F. Schietinger
Director of Research

Reference: Georgia Tech Project No. A-1675

Subject: Monthly Technical Progress and Financial Report No. 6
"Area Manpower Projection Model"

Gentlemen:

A summary of the progress for the period 6 February 1975 through 5 March 1975 is contained herein.

I. Introduction

The overall objectives of this program are the following: (1) to convert approximately six data tapes from IBM System 360 track and parity to Univac 1108 track and parity; (2) to develop a digital program which will accept the Univac 1108-compatible data tapes and appropriately process the data; (3) to apply the program to approximately sixteen data tapes; and (4) to provide assistance to SREB personnel in the integration of the above program and data into an overall manpower projection model program.

II. Technical Progress Summary

The primary tasks were accomplished prior to this reporting period. Current technical activity consists of provisions of Univac 1108 computational time and consulting services as required.

ENGINEERING EXPERIMENT STATION
GEORGIA INSTITUTE OF TECHNOLOGY • ATLANTA, GEORGIA 30332

10 April 1975

Southern Regional Education Board (SREB)
130 Sixth Street, N.W.
Atlanta, Georgia 30313

Attention: Dr. E. F. Schietinger
Director of Research

Reference: Georgia Tech Project No. A-1675

Subject: Monthly Technical Progress and Financial Report No. 7
"Area Manpower Projection Model"

Gentlemen:

A summary of the progress for the period 6 March 1975 through 5 April 1975 is contained herein.

I. Introduction

The overall objectives of this program are the following: (1) to convert approximately six data tapes from IBM System 360 track and parity to Univac 1108 track and parity; (2) to develop a digital program which will accept the Univac 1108-compatible data tapes and appropriately process the data; (3) to apply the program to approximately sixteen data tapes; and (4) to provide assistance to SREB personnel in the integration of the above program and data into an overall manpower projection model program.

II. Technical Progress Summary

The primary tasks were accomplished prior to this reporting period. Current technical activity consists of provisions of Univac 1108 computational time and consulting services as required.

III. Financial Report

Charges expensed for February were $160.27, and the total expensed charges (through February) are $5,572.82, leaving an apparent free balance of $845.18. Charges for recent computer time are yet to be expensed.

Respectfully submitted,

L. D. Holland
Project Director

Approved:

R. P. Zimmer
Manager, Systems Analysis Technical Area
Radar Division

LDH/ja

III. Financial Report

Charges expensed for March were $44.40, and the total expensed charges (through March) are $5,617.22, leaving an apparent free balance of $800.78. Charges for recent computer time are yet to be expensed.

Respectfully submitted,

L. D. Holland
Project Director

Approved:

R. P. Zimmer
Manager, Systems Analysis Technical Area
Radar Division

LDH/ja

ENGINEERING EXPERIMENT STATION
GEORGIA INSTITUTE OF TECHNOLOGY • ATLANTA, GEORGIA 30332

14 May 1975

Southern Regional Education Board (SREB)
130 Sixth Street, N.W.
Atlanta, Georgia 30313

Attention: Dr. E. F. Schietinger
Director of Research

Reference: Georgia Tech Project No. A-1675

Subject: Monthly Technical Progress and Financial Report No. 8
"Area Manpower Projection Model"

Gentlemen:

A summary of the progress for the period 6 April 1975 through 5 May 1975 is contained herein.

I. Introduction

The overall objectives of this program are the following: (1) to convert approximately six data tapes from IBM System 360 track and parity to Univac 1108 track and parity; (2) to develop a digital program which will accept the Univac 1108-compatible data tapes and appropriately process the data; (3) to apply the program to approximately sixteeen data tapes and (4) to provide assistance to SREB personnel in the integration of the above program and data into an overall manpower projection model program.

II. Technical Progress Summary

The primary tasks were accomplished prior to this reporting period. Current technical activity consists of provisions of Univac 1108 computational time and consulting services as required. During this period, the employee separation data from the project's primary output tape was copied onto another tape for SREB transmittal to a potential user.

Many of the results of this project are described in a paper entitled "Computerized Projection of Supply Demand Balances in Southern Higher Education" presented 24 April 1975 at the Sixth Annual Pittsburgh Conference

on Modeling and Simulation (Proceedings to be published). The paper was coauthored by Richard Engels of SREB and by Larry Holland and Ollie Francis of the Engineering Experiment Station.

III. Financial Report

Charges expensed for April were $282.32, and the total expensed charges (through May) are $5,899.54, leaving an apparent free balance of $518.46. Charges for recent computer time are yet to be expensed.

IV. Contract Expiration Date

This project is currently scheduled to terminate on 5 June 1975. The objectives of the tasks to date have been met and the work has been documented in the December 1974 EES report "Area Manpower Projection Model." Since December work on the project has consisted of the supplying of computational facilities and engineering consulting to SREB and no additional technical report will be prepared.

Respectfully submitted,

L. D. Holland
Project Director

Approved:

R. P. Zimmer
Manager, Systems Analysis Technical Area
Radar Division

LDH/ja

A-1675

AREA MANPOWER PROJECTION MODEL

by

L.D. Holland and O.B. Francis

FINAL TECHNICAL REPORT

PROJECT A–1675

Prepared for

SOUTHERN REGIONAL EDUCATION BOARD
ATLANTA, GEORGIA 30313

1974

By

RADAR DIVISION
ENGINEERING EXPERIMENT STATION
Georgia Institute of Technology
Atlanta, Georgia 30332

AREA MANPOWER PROJECTION MODEL

by

L. D. Holland and O. B. Francis

Final Technical Report

Project A-1675

Prepared for

Southern Regional Education Board
Atlanta, Georgia 30313

By

Radar Division
ENGINEERING EXPERIMENT STATION
Georgia Institute of Technology
Atlanta, Georgia 30332

FOREWORD

This research on Area Manpower Projection Modeling was conducted by the Radar Division of the Systems and Techniques Department, Engineering Experiment Station. The program was administered under Georgia Tech Project A-1675 by the Systems Analysis Technical Area of the Radar Division.

This report describes the work performed from 6 September to 6 December 1974. The program was sponsored by the Manpower and Education Project, Southern Regional Education Board (SREB). The project was funded through SREB's Director of Research, Dr. E. F. Schietinger, and technical cognizance at SREB was maintained by Mr. Richard Engels.

Mr. Larry D. Holland served as Project Director for the work at Georgia Tech, and Mr. O. B. Francis developed and applied the computer techniques necessary for accomplishment of the program objectives. The work was performed under the general supervision of Mr. Robert Zimmer, Manager of the Systems Analysis Technical Area and Dr. H. A. Ecker, Chief, Radar Division.

ABSTRACT

The overall objective of this project was the transformation of industry-occupational matrices and projected matrix changes for the nation and for each of the fourteen states within the Southern Region into an industry/occupation categorization consistent with SREB's Area Manpower Projection Model. The task was accomplished in a timely manner, and the project procedure and results are described by this report and the computer tape delivered to SREB. The tape contains both the transformed data and the computer programs developed during the project.

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AREA MANPOWER PROJECTION MODEL

I. Introduction

In a growing economy, the occupational composition of the work force, as well as the skills required in each occupation, change through the years. Present manpower needs, therefore, are an uncertain guide to future requirements. To plan education and training programs to meet tomorrow's manpower needs, projections are needed of these changing manpower requirements. Such projections can help also in the vocational guidance of young people. To the extent that education, training, and vocational guidance accurately reflect the changing character of manpower needs, imbalances between manpower requirements and labor supply can be reduced, the productivity of the economy and the earning power of workers enhanced, and structural unemployment minimized.

The Southern Regional Education Board (SREB) is preparing such an estimate (projection) of the supply and demand for workers in various occupations within the Southern Region (14 states) for the 1970-1980 period. The estimate is to be based upon national and local statistics and will utilize projection models similar to those available from the Bureau of the Census and the U. S. Department of Labor [1]. The basic occupational data from the Bureau of the Census have been interpreted, transformed and tailored for SREB use by the Engineering Experiment Station at Georgia Tech. This report briefly describes the projection model and the data transformations required for application of the model to specific Southern Region states by SREB.

The project's primary deliverable item is a computer tape containing (1) occupational separation rates for each of the fourteen states in the Southern Region, (2) the element-by-element ratios of the national industry-occupational matrices (1980 over 1970), (3) the state industry-occupational matrix for each Southern Region state, in alphabetical order, (4) the 1970 national industry-occupational matrix, (5) the 1980 national industry-occupational matrix, and (6) a record of the computer programs and subroutines developed during the project. The industry-occupational matrices on the tape use the SREB industry and occupation categories described in Tables I and II of this report. The deliverable tape was made available to SREB in mid-November, 1974.

II. Projections of Occupational Requirements

The future total employment levels of individual industries are primary factors which influence future occupational requirements since each industry has a unique occupational structure. For example, a sharp change in total employment in the construction industry will have a significant effect upon the need for blue collar workers such as carpenters, electricians and laborers. On the other hand, a sharp reduction in total employment in the insurance industry will result in significant reduction in the need for white collar workers. The estimation of future employment in individual industries is a required step in the projection of occupational employment requirements, i.e., in predicting the number of employees required in each occupational category at some future time.

The occupational structure for an industry is described by a column matrix whose i^{th} entry is the fraction of the industry's employment which

works within occupation i. A rectangular matrix constructed by placing the column occupational matrices for all industries side-by-side is called the industry-occupational matrix and is the accepted method for describing the occupational structure of all the industries. The parameter f_{ij} (i.e., the element in the i^{th} row and the j^{th} column) is that fraction of the total emeployment of industry j employed in occupation i.

The second factor in occupational employment is the change with time of those unique occupational structures of each industry. The application of new technology, changes in establishment size, the development of new products, etc., are occurring constantly within an industry. These and other factors result in growth of the relative requirements for some occupations within an industry, and at the same time reduce the relative need for other occupations.

The U. S. Bureau of Census and the U. S. Department of Labor's Bureau of Labor Statistics provide industry-occupation matrices for the United States as a whole and for individual states for the most recent census year (1970); they also provide their estimate of the U. S. industry-occupational matrix for the coming census year (1980). It is toward the application of these data to estimation of state or regional matrices for the coming census year (1980) that this study has been directed.

A. Projection Model for an Area

The U. S. projected industry-occupational matrix can be used to generate a local projected industry-occupational matrix which can then be used with a projection of local industry employment to predict local occupational requirements at the projected future time. Such a method of predictions

combines the effects of predicted local variations in industry employment levels with time-changes in the (unique) industry occupational structures which are best predicted on a national level. The method selected by SREB for application of the projected 1980 U. S. matrix is described mathematically as follows:

$$L_j(80) = \sum_{i=1}^{n} \{L_{ij}^*(80) \cdot L_i(80)\} \qquad (1)$$

with

$$L_{ij}^*(80) = \frac{f_{ij(80)}}{f_{ij}(70)} \cdot L_{ij}^*(70), \qquad (2)$$

where L_i is the total local employment in dustry i, L_j is the total local employment in occupation j, L_{ij}^* is the local fraction of occupation j in industry i, and f_{ij} is the national fraction of occupation j in industry i. The arguements in parenthesis are the year numbers; i.e., $L_j(80)$ is the projected 1980 value of L_j. Note also that f_{ij} and L_{ij} are the i^{th} row, j^{th} column elements of the national and local industry-occupational matrices respectively.

Equation (1) is just an applicaton of the definition of the industry-occupational matrix to the estimation of the number of employees required in occupation j in the state or region being studied. Equation (2) establishes the value of the i,j element of the projected (1980) local matrix from a know past value (1970) and a knowledge of how the corresponding element of the national matrix changed between the same years.

B. Industry and Occupation Categories

In order to apply equations (1) and (2) for development of local projections of occupational needs, the input data representing local and national quantities must be expressed in terms of the same sets of industry categories and occupation categories. Performance of this project required incorporation of three large data files from separate sources (two from federal agencies and one from private industry) into a single computerized projection model. The categories being used in the current SREB study contain 44 industries and 421 occupations, and are itemized in Tables I and II respectively. However, the input state industry-occupational matrices (L*) use significantly different categories, with a total of 227 industries and 440 occupations, while the input national matrices (1970 and 1980) are in still another categorization.

The remainder of this report summarizes the work performed by Georgia Tech on the transformation of the fifteen magnetic tapes of Census Bureau data to the categorization and format required by SREB for implementation of its manpower projection program. The initial data included 1970 industry-occupational matrices for 14 states and the nation, the projected 1980 national industry-occupational matrix, and a matrix containing separation rates by occupation by states. The i,j element of the latter matrix represents the fractional part of those members of the i^{th} occupation in the j^{th} state who leave that occupation during a period of one year.

III. Response to Project Tasks

The following contains a brief description of the response to each of the eight tasks of the project.

TABLE I. SREB Industry Sequence

Number	Industry
1	Agricultural Production
2	Other Agriculture, Forestry, and Fisheries
3	Metal Mining
4	Coal Mining
5	Petroleum and Natural Gas Extraction
6	Nonfuel, Nonmetallic Mining and Quarrying
7	General Building Contracting
8	Nonbuilding General
9	Special Trade Contracting
10	Logging, Mills, and Wood Products
11	Furniture and Fixtures
12	Stone, Clay, and Glass Products
13	Primary Nonferrous Industries
14	Miscellaneous Fabricated Metal Products
15	Machinery Except Electric
16	Electrical Equipment and Supplies
17	Transportation Equipment
18	Instruments
19	Ordnance
20	Miscellaneous Manufacturing
21	Food and Kindred Products
22	Tobacco Manufacturing
23	Textile Mill Products
24	Apparel and Fabricated Textile Products
25	Pulp and Paper Products
26	Printing and Publishing
27	Chemicals and Allied Products
28	Petroleum and Coal Products
29	Rubber and Plastic Products
30	Leather and Leather Products
31	Transportation Services
32	Communication Services

TABLE I (Continued)

Number	Industry
33	Public Services
34	Wholesale Trade
35	Retail Trade
36	Finance
37	Insurance
38	Real Estate
39	Business and Repair Services
40	Private Household Services
41	Personal, Entertainment, and Recreational Services
42	Professional Services
43	Federal Public Administration
44	State and Local Public Administration

TABLE II

SREB Occupations and Sequence

Sequence Number	Occupation	Sequence Number	Occupation
1	Accountants	33	Physicists and Astronomers
2	Architects	34	Other Life and Physical Scientists
3	Computer Programmers	35	Operations and Systems Res. and Analysts
4	Computer Systems Analysts	36	Personnel and Labor Relations Workers
5	Computer Specialists (Other)	37	Chiropractors
6	Aeronautical and Astronautical Engineers	38	Dentists
7	Chemical Engineers	39	Optometrists
8	Civil Engineers	40	Pharmacists
9	Electrical and Electronic Engineers	41	Physicians, Medical and Osteopathic
10	Industrial Engineers	42	Podiatrists
11	Mechanical Engineers	43	Veterinarians
12	Metallurical and Materials Engineers	44	Other Health Practitioners
13	Mining Engineers	45	Dietitians
14	Petroleum Engineers	46	Registered Nurses
15	Sales Engineers	47	Therapists
16	Other Engineers	48	Clinical Lab. Technologists and Technics
17	Farm Management Advisors	49	Dental Hygientists
18	Foresters and Conservationists	50	Health Record Technologists and Technician
19	Home Management Advisors	51	Radiologic Technologists and Technicians
20	Judges	52	Therapy Assistants
21	Lawyers	53	Other Health Technologists and Technicians
22	Librarians	54	Clergymen
23	Archivists and Curators	55	Other Religious Workers
24	Actuaries	56	Economists
25	Mathematicians	57	Political Scientists
26	Statisticians	58	Psychologists
27	Agricultural Scientists	59	Sociologists
28	Atmospheric and Space Scientists	60	Urban and Regional Planners
29	Biological Scientists	61	Other Social Scientists
30	Chemists	62	Social Workers
31	Geologists	63	Recreation Workers
32	Marine Scientists	64	Agriculture Teachers

TABLE II (continued)

Sequence Number	Occupation	Sequence Number	Occupation
65	Atmosphere, Earth, Marine & Space Teachers	98	Industrial Engineering Technicians
66	Biology Teachers	99	Mechanical Engineering Technicians
67	Chemistry Teachers	100	Mathematical Technicians
68	Physics Teachers	101	Surveyors
69	Engineering Teachers	102	Other Engineering & Science Technicians
70	Mathematics Teachers	103	Airplane Pilots
71	Health Specialties Teachers	104	Air Traffic Controllers
72	Psychology Teachers	105	Embalmers
73	Business and Commercial Teachers	106	Flight Engineers
74	Economics Teachers	107	Radio Operators
75	History Teachers	108	Tool Programmers, Numerical Control
76	Sociology Teachers	109	Other Technicians
77	Other Social Science Teachers	110	Vocational and Educational Counselors
78	Art, Drama, and Music Teachers	111	Actors
79	Coaches and Physical Education Teachers	112	Athletes and Kindred Workers
80	Education Teachers	113	Authors
81	English Teachers	114	Dancers
82	Foreign Language Teachers	115	Designers
83	Home Economics Teachers	116	Editors and Reporters
84	Law Teachers	117	Musicians and Composers
85	Theology Teachers	118	Painters and Sculptors
86	Trade, Industrial, & Technical Teachers	119	Photographers
87	Miscellaneous Teachers, College & Univ.	120	Public Relations Men & Publicity Writers
88	Other Teachers, College and University	121	Radio and Television Announcers
89	Adult Education Teachers	122	Other Writers, Artists, and Entertainers
90	Elementary School Teachers	123	Research Workers, Subject Not Specified
91	Prekindergarten & Kindergarten Teachers	124	Assessors & Treas., Local Pub. Admin.
92	Secondary School Teachers	125	Bank Officers and Financial Managers
93	Other Teachers, Except College & University	126	Buyers and Shippers, Farm Products
94	Ag. & Biological Tech., Except Health	127	Buyers, Wholesale and Retail Trade
95	Chemical Technicians	128	Credit Men
96	Draftsmen	129	Funeral Directors
97	Electrical & Electronic Engin. Technicians	130	Health Administrators

TABLE II

SREB Occupations and Sequence

Sequence Number	Occupation
131	Construction Inspectors, Public Admin.
132	Inspectors, Exc. Construction, Pub. Ad.
133	Managers and Superintendents, Building
134	Other Office Managers
135	Officers, Pilots, and Pursers, Ship
136	Other Officials & Admin, Public Admin.
137	Officials of Lodges, Societies, and Unions
138	Postmasters and Mail Superintendents
139	Other Purchasing Agents and Buyers
140	Railroad Conductors
141	Restaurant, Cafeteria, and Bar Managers
142	Sales Managers & Dept. Heads, Ret. Trade
143	Sales Managers, Except Retail Trade
144	School Administrators, College
145	School Administrators, Elementary & Sec.
146	Other Managers and Administrators
147	Advertising Agents and Salesmen
148	Auctioneers
149	Demonstrators
150	Hucksters and Peddlers
151	Insurance Agents and Brokers
152	Newsboys
153	Real Estate Agents and Brokers
154	Stock and Bond Salesmen
155	Sales Representatives, Manuf. Industries
156	Sales Representatives, Wholesale Trade
157	Sales Clerks, Retail Trade
158	Salesmen, Retail Trade
159	Salesmen of Services and Construction
160	Bank Tellers
161	Billing Clerks
162	Bookkeepers
163	Cashiers
164	Clerical Assistants, Social Welfare
165	Other Clerical Supervisors
166	Collectors, Bill and Account
167	Counter Clerks, Except Food
168	Dispatchers and Starters, Vehicle
169	Enumerators and Interviewers
170	Other Estimators and Investigators
171	Expediters and Production Controllers
172	File Clerks
173	Insurance Adjusters and Examiners
174	Library Attendants and Assistants
175	Mail Carriers, Post Office
176	Mail Handlers, Except Post Office
177	Messengers and Office Boys
178	Meter Readers, Utilities
179	Bookkeeping and Billing Machine Operator
180	Calculating Machine Operators
181	Computer and Peripheral Equipment Operator
182	Duplicating Machine Operators
183	Key Punch Operators
184	Tabulating Machine Operators
185	Other Office Machine Operators
186	Payroll and Timekeeping Clerks
187	Postal Clerks
188	Proofreaders
189	Real Estate Appraisers
190	Receptionists
191	Secretaries, Legal
192	Secretaries, Medical
193	Other Secretaries
194	Shipping and Receiving Clerks

TABLE II (Continued)

SREB Occupations and Sequence

Sequence Number	Occupation	Sequence Number	Occupation
195	Statistical Clerks	228	Excav. & Grading Mach. Oper., Ex. Bull.
196	Stenographers	229	Floor Layers, Except Tile Setters
197	Stock Clerks and Storekeepers	230	Other Foremen
198	Teacher Aides, Except School Monitors	231	Forgemen and Hammermen
199	Telegraph Operators	232	Furniture and Wood Finishers
200	Telephone Operators	233	Furriers
201	Ticket, Station, and Express Agents	234	Glaziers
202	Typists	235	Heat Treaters, Annealers, Temperers
203	Weighers	236	Inspectors and Graders, Log & Lumber
204	Misc. And Not Specified Clerical Workers	237	Other Inspectors
205	Automobile Accessories Installers	238	Jewelers and Watchmakers
206	Bakers	239	Job and Die Setters, Metal
207	Blacksmiths	240	Locomotive Engineers
208	Boilermakers	241	Locomotive Firemen
209	Bookbinders	242	Machinists
210	Brickmasons and Stonemasons	243	Machinist Apprentices
211	Brickmason and Stonemason Apprentices	244	Air Conditioning, Heating, and Refrig.
212	Bulldozer Operators	245	Aircraft
213	Cabinetmakers	246	Automobile Body Repairmen
214	Carpenters	247	Automobile Mechanics
215	Carpenter Apprentices	248	Automobile Mechanics Apprentices
216	Carpet Installers	249	Data Processing Machine Repairmen
217	Cement and Concrete Finishers	250	Farm Implement
218	Compositors and Typesetters	251	Heavy Equipment Mechanics, Inc. Diesel
219	Printing Trades Apprent., Exc. Pressmen	252	HH Appliance & Acc. Installers & Mechs.
220	Cranemen, Derrickmen, and Hoistmen	253	Loom Fixers
221	Decorators and Window Dressers	254	Office Machine
222	Dental Laboratory Technicians	255	Radio and Television
223	Electricians	256	Railroad and Car Shop
224	Electrician Apprentices	257	Mechanic Apprentices, Except Auto
225	Electric Power Linemen and Cablemen	258	Misc. & Not Specified Mech. & Repairmen
226	Electrotypers and Stereotypers	259	Millers, Grain, Flour, and Feed
227	Engravers, Except Photoengravers	260	Millwrights

TABLE II (Continued)

SREB Occupations and Sequence

Sequence Number	Occupation	Sequence Number	Occupation
261	Molders, Metal	294	Upholsterers
262	Molder Apprentices	295	Other Specified Craft Apprentices
263	Motion Picture Projectionists	296	Other Craftsmen and Kindred Workers
264	Opticians, and Lens Grinders and Polishers	297	Former Members of the Armed Forces
265	Painters, Construction and Maintenance	298	Asbestos and Insulation Workers
266	Painter Apprentices	299	Assemblers
267	Paperhangers	300	Blasters and Powdermen
268	Pattern and Model Makers, Except Paper	301	Bottling and Canning Operatives
269	Photoengravers and Lithographers	302	Chainmen, Rodmen, and Axmen. Surveying
270	Piano and Organ Tuners and Repairmen	303	Checkers, Examiners, & Inspectors, Man.
271	Plasterers	304	Clothing Ironers and Pressers
272	Plasterer Apprentices	305	Other Cutting Operatives
273	Plumbers and Pipe Fitters	306	Dressmakers & Seamstresses, Exc. Factory
274	Plumber and Pipe Fitter Apprentices	307	Drillers, Earth
275	Power Station Operators	308	Dry Wall Installers and Lathers
276	Pressmen and Plate Printers, Printing	309	Dyers
277	Pressmen Apprentices	310	Filers, Polishers, Sanders, and Buffers
278	Rollers and Finishers, Metal	311	Furnacemen, Smeltermen, and Pourers
279	Roofers and Slaters	312	Garage Workers and Gas Station Attendant
280	Sheetmetal Workers and Tinsmiths	313	Graders and Sorters, Manufacturing
281	Sheetmetal Apprentices	314	Produce Grader, Pac., Exc. Fact. & Farm
282	Shipfitters	315	Heaters, Metal
283	Shoe Repairmen	316	Other Laundry & Dry Cleaning Operatives
284	Sign Painters and Letterers	317	Meat Cutters and Butchers, Except Manufa
285	Stationary Engineers	318	Meat Cutters and Butchers, Manufacturing
286	Stone Cutters and Stone Carvers	319	Meat Wrappers, Retail Trade
287	Structural Metal Craftsmen	320	Metal Platers
288	Tailors	321	Milliners
289	Telephone Installers and Repairmen	322	Other Mine Operatives
290	Telephone Linemen and Splicers	323	Mixing Operatives
291	Tile Setters	324	Oilers and Greasers, Except Auto
292	Tool and Die Makers	325	Packers & Wrappers, Exc. Meat & Produce
293	Tool and Die Maker Apprentices	326	Painters, Manufactured Articles

TABLE II (Continued)

SREB Occupations and Sequence

Sequence Number	Occupation	Sequence Number	Occupation
327	Photographic Process Workers	361	Carpenter's Helpers
328	Drill Press Operatives	362	Construction Laborers, Exc. Carp. Helps.
329	Grinding Machine Operatives	363	Fishermen and Oystermen
330	Lathe and Milling Machine Operatives	364	Freight and Material Handlers
331	Other Precision Machine Operatives	365	Garbage Collectors
332	Punch and Stamping Press Operatives	366	Gardeners and Groundskeepers, Exc. Farm.
333	Riveters and Fasteners	367	Longshoremen and Stevedores
334	Sailors and Deckhands	368	Lumbermen, Raftsmen, and Woodchoppers
335	Sawyers	369	Stock Handlers
336	Sewers and Stitchers	370	Teamsters
337	Shoemaking Machine Operatives	371	Vehicle Washers and Equipment Cleaners
338	Solderers	372	Other Warehousemen
339	Stationary Firemen	373	Miscellaneous and Not Specified Laborers
340	Carding, Lapping, and Combing Operatives	374	Farmers (Owners and Tenants)
341	Knitters, Loopers, and Toppers	375	Farm Managers
342	Spinners, Twisters, and Winders	376	Farm Foremen
343	Weavers	377	Farm Laborers, Wage Workers
344	Other Textile Operatives	378	Farm Laborers, Unpaid Family Workers
345	Welders and Flame-Cutters	379	Farm Service Laborers, Self-employed
346	Other Winding Operatives	380	Chambermaids and Maids, Except Pri. HH.
347	Machine Operatives, Misc. & Not Spec.	381	Cleaners and Charwomen
348	Miscellaneous & Not Specified Operatives	382	Janitors and Sextons
349	Boatmen and Canalmen	383	Bartenders
350	Bus Drivers	384	Busboys
351	Conductors & Motormen, Urban Rail Trans.	385	Cooks, Except Private Household
352	Deliverymen and Routemen	386	Dishwashers
353	Fork Lift and Tow Motor Operatives	387	Food Counter and Fountain Workers
354	Motormen, Mine, Factory, Logging, Etc.	388	Waiters
355	Parking Attendants	389	Other Food Service Workers, Exc. Pri. HH
356	Railroad Brakemen	390	Dental Assistants
357	Railroad Switchmen	391	Health Aides, Except Nursing
358	Taxicab Drivers and Chauffeurs	392	Health Trainees
359	Truck Drivers	393	Lay Midwives
360	Animal Caretakers, Except Farm	394	Nursing Aides, Orderlies, and Attendants

TABLE II (Continued)

SREB Occupations and Sequence

Sequence Number	Occupation
395	Practical Nurses
396	Airline Stewardesses
397	Attendants, Recreation and Amusement
398	Other Attendants, Personal Service
399	Baggage Porters and Bellhops
400	Barbers
401	Boarding and Lodging Housekeepers
402	Bootblacks
403	Child Care Workers, Except Private HH.
404	Elevator Operators
405	Hairdressers and Cosmetologists
406	Personal Service Apprentices
407	Housekeepers, Except Private Household
408	School Monitors
409	Ushers, Recreation and Amusement
410	Welfare Service Adies
411	Crossing Guards and Bridge Tenders
412	Firemen, Fire Protection
413	Guards and Watchmen
414	Marshals and Constables
415	Policemen and Detectives
416	Sheriffs and Bailiffs
417	Child Care Workers, Private Household
418	Cooks, Private Household
419	Housekeepers, Private Household
420	Laundresses, Private Household
421	Maids and Servants, Private Household

Under Task I, any input data computer tapes recorded in a form not compatible with the Univac 1108 were to be converted to a compatible form. The tape containing the national data and four of the state industry-occupational matrix tapes (Alabama, North Carolina, Virginia, and Tennessee) were supplied to EES in IBM-compatible 9-track form and were converted (at the Georgia State University Computer Center) to the 7-track form accepted by the Univac 1108 system. The only irregularity encountered in the conversion was that blank elements in the original tapes were presented as ampersand characters in the converted tapes; however, this presented no difficulty in the use of the converted tapes.

One unexpected difficulty was encountered in attempting to read the data tapes into the computer. The length of the blocks of characters (physical records) recorded on the input tapes exceeded 132 characters so that FORTRAN statements could not be used to read the tapes. The problem was solved by using NTRAN in reading the data from the tapes. The use of NTRAN provided an additional benefit in significant reduction in computer time required for reading the massive amounts of data.

Under Task II, twelve submatrices (per state) were summed to yield the state industry-occupational matrix for each of the fourteen states. The input tapes contained separate matrices for twelve employee classifications: (1) private company, (2) federal government, (3) state government, (4) local government, (5) self-employed, and (6) working without pay; with each further divided as to male or female worker. The significance of the above summations is in the size of each matrix (227 x 440). A special subroutine for summing was developed which takes advantage of the many zero-value elements

within the matrices in order to reduce computer time requirements by at least one order of magnitude (factor of 10).

Under Task III, the matrix entries under industry or occupation headings which included the word "allocated" were redistributed among the appropriate non-allocated entries. For example, the first few industry categories in the input data were as follows:

1. Agricultural Production
2. Agricultural Services, Except Horticultural
3. Horticultural Services
4. Forestry
5. Fisheries
6. Agriculture, Forestry, and Fisheries--Allocated
7. Metal Mining

In this task, the number in the 6th row of each column was distributed over the first 5 rows in proportion to the original entries in those rows of the column. The details of which industries and occupations were allocated and how they were distributed are included in the computer program record on the delivered computer tape. Allocation was performed for all 14 states.

Under Task IV, various industries (and some occupations) were aggregated, or combined, in order to transform the categorizations to those to be used by SREB. The task involved group summation and reordering, and was performed for each of the 14 state matrices. The result was a 421 by 44 industry-occupational matrix for each state. As a numerical check on the accuracy of the computer processing up to this point, column sums were obtained and compared with similar sums for the original input data.

Task V, as specified in the proposal, called for operations on two additional computer tapes; however, when that data arrived, it was contained

on a single tape. It had been anticipated that the 1970 and 1980 national industry-occupational matrices contained on this tape would be processed using the programs developed for and used earlier on the state matrices. However, the national matrices turned out to use yet another set of industry and occupation categories, and to be recorded on the tape in a different word length than used on the state tapes. As a result, it was necessary to develop additional computer subroutines for reading, and aggregating the national matrices.

Additional processing required just for the national matrices included generation of a matrix whose elements are the ratios of similar elements of the 1980 national matrix to those of the 1970 national matrix. These values correspond to the ratio $f_{ij}(80)/f_{ij}(70)$ in Equation (2). Also included under this task was the interpretation and transformation of the occupational separation data, by states.

Task VI required the generation of the deliverable computer tape containing all numerical results (state and national industry-occupational matrices, separation data, and national matrix ratios). This was accomplished ahead of schedule.

Task VII calls for documentation of the models and computer programs developed during the project. The earlier portion of this report documents the model; this report, together with the delivered tape, documents the computer programs developed. The tape contains a complete record of the 16 programs and 40 subprograms developed for accomplishing the above tasks, their total length (approximately 50 pages) makes it impractical to include program listings in this report.

The deliverable computer tape, which was used at Georgia Tech under the name SREBTAPE and reel number U1869N, contains the project output data in the following sequence: (1) occupational separation rates for the fourteen states, in alphabetical order, (2) national industry-occupational matrix ratios, (3) the fourteen state matrices, in alphabetical order, (4) the 1970 national matrix, (5) the 1980 national matrix, and (6) the programs developed during the project. The first "end of file" mark is at the end of the 1980 national matrix. All data is written in FIELDATA format and may require conversion to BCD for use on a computer other than the Univac 1108 system. The programs themselves can be read from the tape by use of the FURPUR processor COPIN statement. Each tape logical record for industry-occupational matrices represents a specific industry and all occupations. For the separation matrix, a logical record represents a specific state and the entire range of occupations.

Task VIII, which calls for provision of technical assistance to SREB in the overall manpower projection model to the extent allowed by funds remaining after completion of the preceeding seven primary tasks, was not implemented. The unexpected necessity of developing separate computer programs for the national industry-occupational matrices, rather than using the ones developed for the state matrices, resulted in expenditure of all available funds to accomplish the primary tasks.

IV. Conclusions

All primary tasks were accomplished and end-items delivered in a timely manner.

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